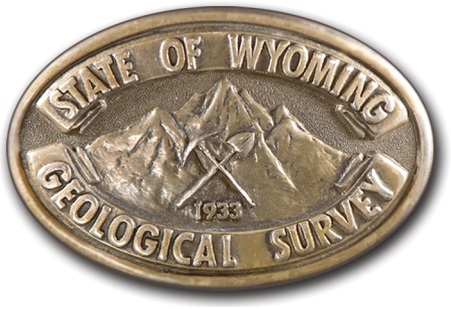

The Well Catalog: Requirement for Geologic CO_2 Storage under Class VI Well Permits

Explanation and Summary

May 2013

Robert Kirkwood[1] *and James D. Myers*[1]

This report was prepared under contract for the Wyoming Department of Environmental Quality by the Wyoming Geological Survey (WSGS).

---

[1]*University of Wyoming, Department of Geology and Geophysics, P.O. Box 3006, Laramie, Wyoming 82071-3006*

Background

The U.S. Environmental Protection Agency (EPA) added the new Class VI well category to its Underground Injection Control (UIC) program for the purpose of geologic storage of CO_2. The UIC program is designed to protect underground sources of drinking water from materials injected into the subsurface. The CO_2 must be stored under a formation that will provide a seal that will keep the CO_2 trapped in the subsurface. The formation that the CO_2 will be stored in is called the reservoir. This type of CO_2 storage is defined as Geologic Carbon Sequestration (GCS).

Permitting a Class VI well requires identifying an Area of Review (AOR). The AOR boundary is based on computer models of subsurface geology and predictions of how the resultant CO_2 plume will grow and migrate as injection proceeds over the lifetime of a project. Within the AOR, all artificial penetrations (such as oil and gas wells, disposal wells, water wells, solution mining wells, etc.) that intersect the seal and reservoir formations must be identified and assessed for CO_2 leakage risk.

Geologic modeling of a GCS site is critically dependent upon accurate data from the existing wells within the AOR. Useful data for risk assessment and modeling are well location, geologic formations penetrated, total well depth, and formation porosity and permeability.

Well locations are some of the most important data for accessing a potential geological sequestration site. Scientists use well locations to build static three-dimensional models of subsurface geology that are subsequently used to model how CO_2 will move in the subsurface. These models predict the migration of the injected CO_2 plume through geologic formations over time. Accurate well locations are also needed to evaluate the risk level of each well for leakage.

The best tool for managing well data is a Geographic Information System (GIS). GIS can store attribute tables, pictures, well logs, and other information related to the wells in a file geodatabase. A geodatabase is the best tool because of the spatial component and the longevity of the project. This type of geodatabase is termed a well catalog. The well catalog can be shared with everyone involved on the project (Figure 1).

Data used for this project were downloaded from the Wyoming Oil and Gas Conservation Commission (WOGCC) Web page, a publicly available data set at http://wogcc.state.wy.us/. The data are in a native database file (.dbf)

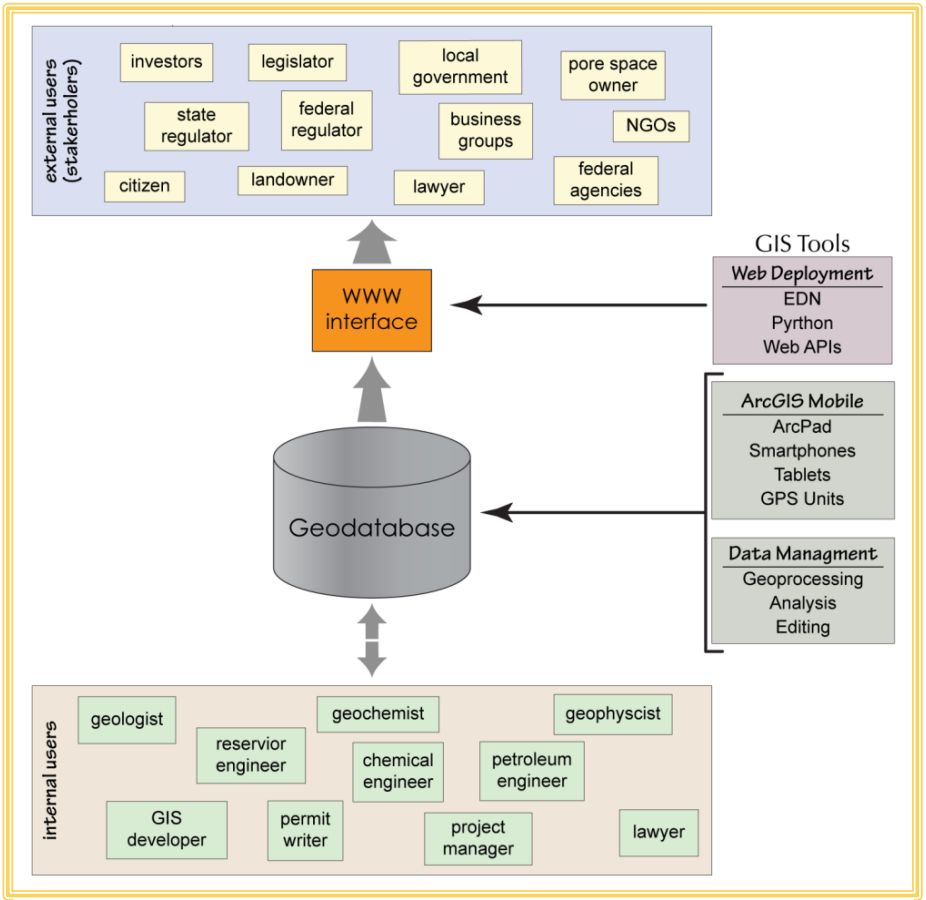

Figure 1. Development of the well catalog geodatabase.

that can be opened in Microsoft Excel or any database program. The data are downloaded as two separate tables that include active and abandoned wells. The tables can be loaded into a well catalog using ArcGIS. The tables contain 42 columns that describe the borehole and/or the formations and fluids it intersects. Only oil and gas wells were used for this project. For a full site characterization under new EPA Class VI rules, CO_2 sequestration projects will need to consider all other classes of wells such as underground injection, water, and exploration boreholes.

Details

Two oil and gas fields in Wyoming were selected as examples for this study: the Moxa arch area and Mahoney Dome (Figure 2). Because the investigation did not use a computational model, the spatial footprint of the Moxa arch AOR was determined by a seismic footprint. The AOR for Mahoney Dome was designated from the oil and gas field outline provided by the Wyoming State Geological Survey (WSGS).

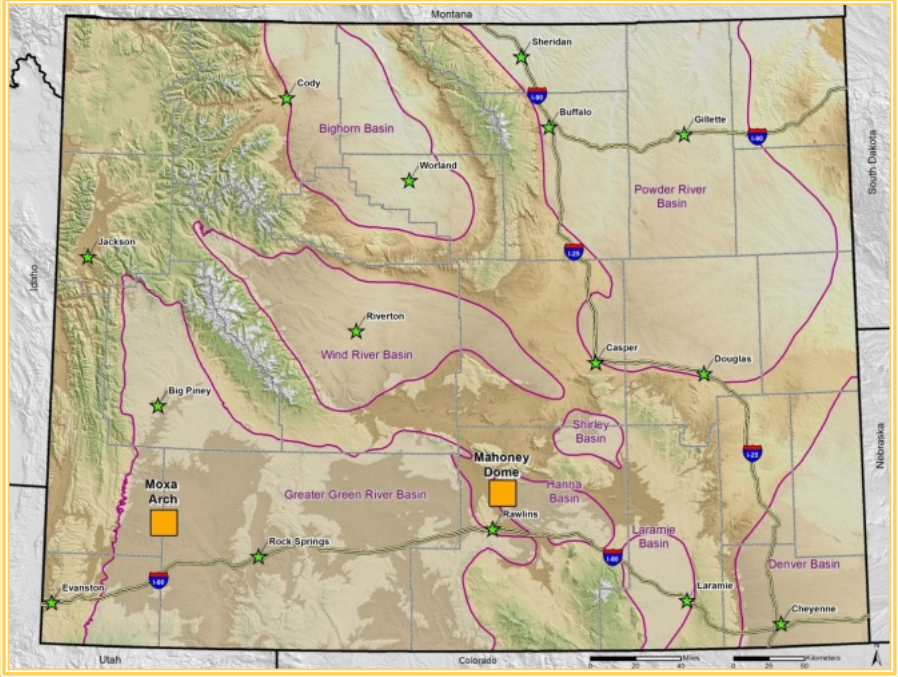

Figure 2. Location map showing Moxa arch and Mahoney Dome, Wyoming.

ArcGIS was used to identify and clip wells from the statewide WOGCC dataset that fell within these areas. The wells were loaded into the well catalog as a separate set of data for on-the-ground location verification. Additional columns were added to the well table, including: field tech, field status, date collected, and comments. The field status describes the location of the well, such as good location, missing well, mined over, proposed-well, or updated location. The wells in the well catalog are later used for the analysis of location accuracy, the geologic model, and risk analysis.

The Moxa arch AOR contains 125 wells (Figure 3A), whereas the Mahoney Dome AOR encompasses 59 wells (Figure 3B). The locations of all wells were verified from air photos and by field reconnaissance on the ground.

The field reconnaissance verification process involved several steps. First, a basemap was created in ArcMap that included air photos, wells, access routes, and landowner information. The data were checked out to a GPS device using the ArcPad extension. Routes to the wells were mapped from the most recent air photos to enable the field technician easier access to the well. The GPS units included a Trimble Pathfinder GPS linked through Bluetooth to a Trimble Yuma tablet (Figure 4). The air photos provided the field technician with the ability to find alternate routes to the well in case that the planned route proved impractical. Within the Moxa

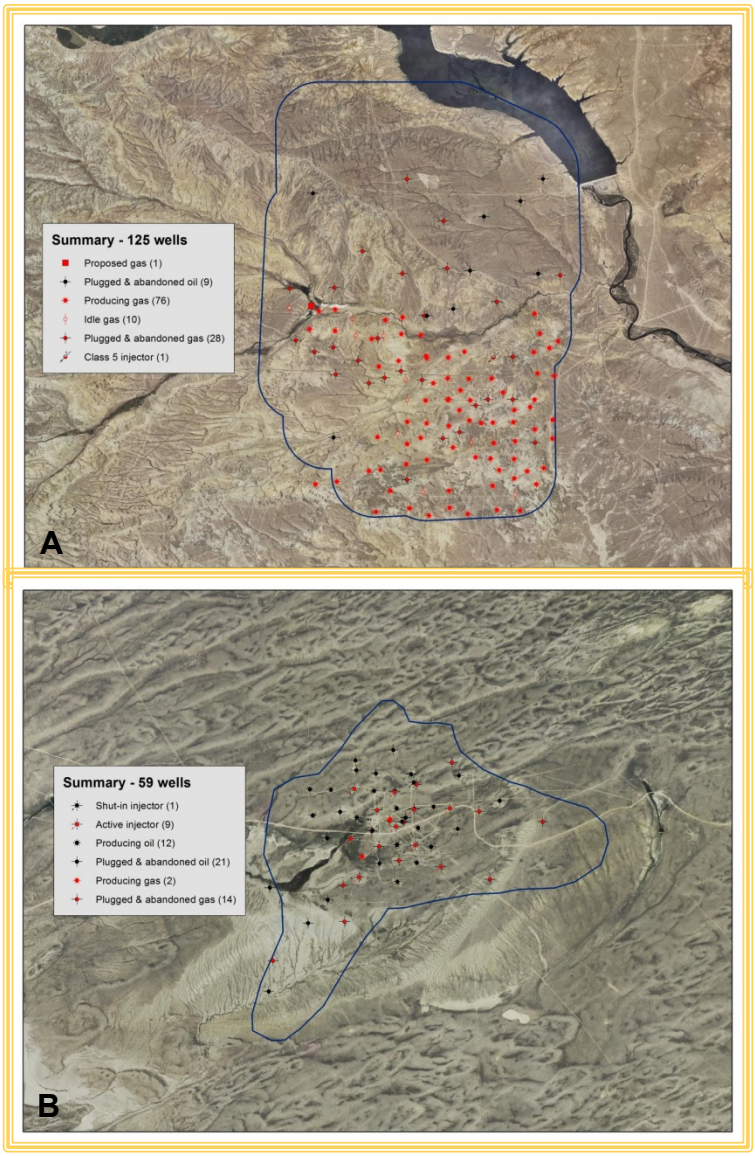

Figure 3. Area of Review (AoR) for **A.** Moxa arch and **B.** Mahoney Dome.

arch AoR, one planned route could not be used due to a washed out bridge. The air photo was then used to locate another road to the well site (Figure 5).

Once a well was physically located in the field, the GPS unit was used to collect the updated location, well status, date collected, and comments. Comments were added that included observations about the well site. For example: Is a well placard present? Is there trash on the well pad? Is the well site reachable by road or on foot? A set of three photos were also taken of each well site — two of the stinger or placard and one of the overall wellpad. A GPS tracklog was also collected to map out the best route to the well. Some wells were absent due to mislocation, or missing or nonexistent placards or stingers. Other wells were only proposed and never drilled. The field reconnaissance verified wells were linked to photos taken at the well site in ArcGIS.

Figure 4. Trimble Pathfinder GPS linked through Bluetooth to a Trimble YUMA tablet with ArcPad extension.

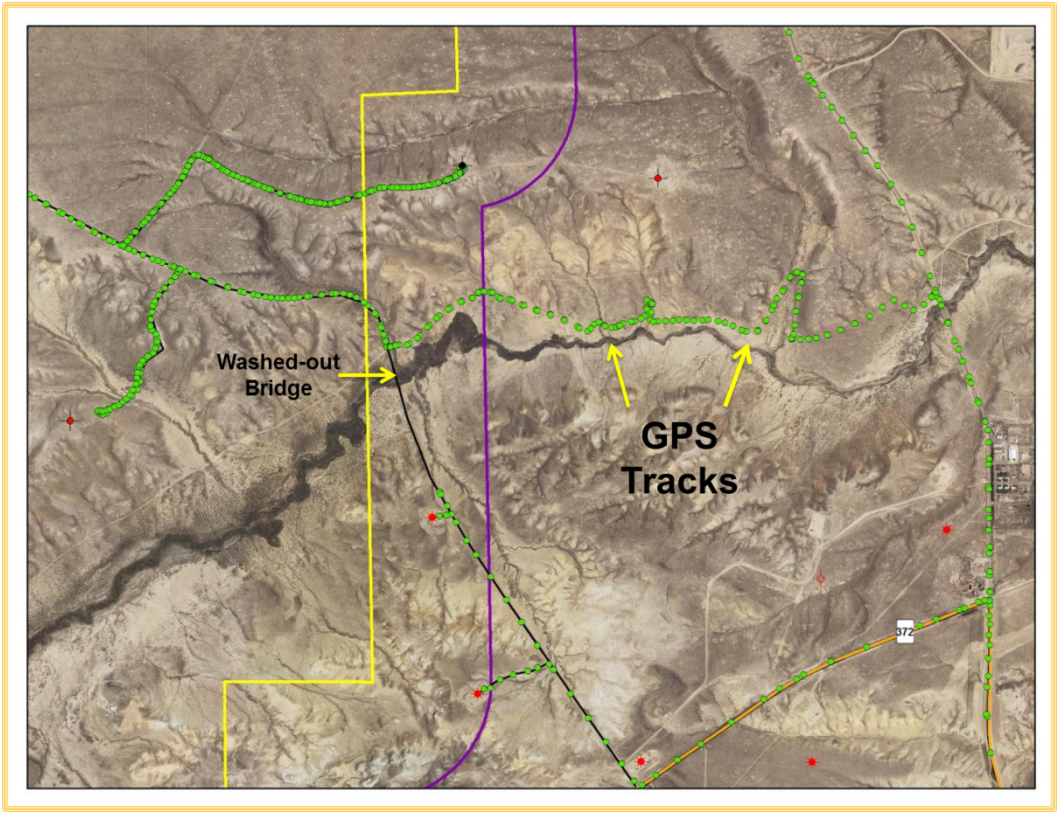

Figure 5. GPS track showing route to wells avoiding a washed-out bridge.

After all of the wells were located the data were loaded back into the well catalog. The data were analyzed for location accuracy using the points to line tool in ArcMap. This tool calculates the distance from the reported WOGCC well location to the new updated location in feet (Figure 6). In the Moxa arch AOR, there were 34 wells that were mislocated by 75 feet or more with the largest error more than one mile. In the Mahoney Dome AOR, 22 wells were displaced more than 100 feet with the largest error 4,700 feet.

To visually analyze and check the data, a basemap was made for use with the HTML pop-up tool. This tool allows the user to select a well and see all of the data related to it. There is also a field in the data table of the wells that lets the user open up the well on the WOGCC Web page to see other information such as change of operator and water chemistry, if available. The user can also use the HTML pop-up tool to see well pictures, sundries, well logs, and well permits (Figure 7).

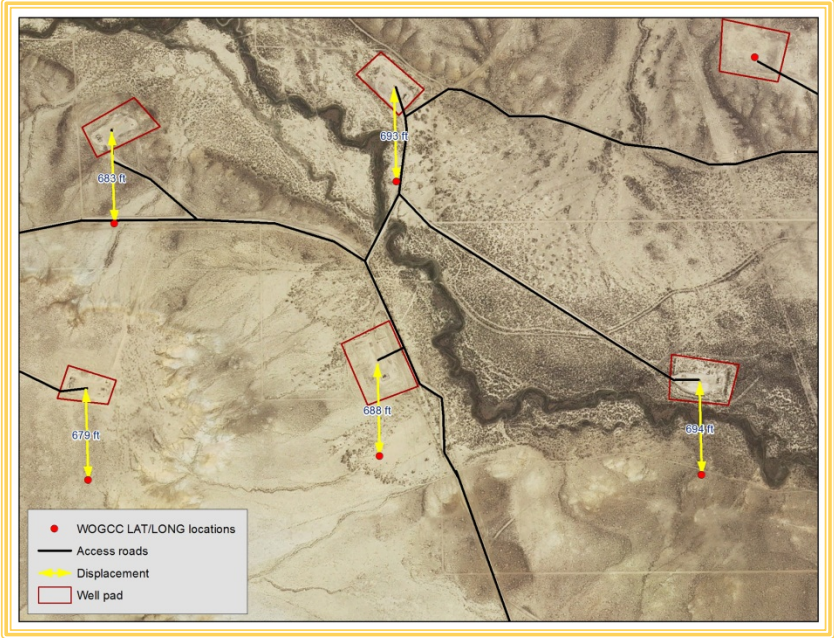

Figure 6. Well location verification.

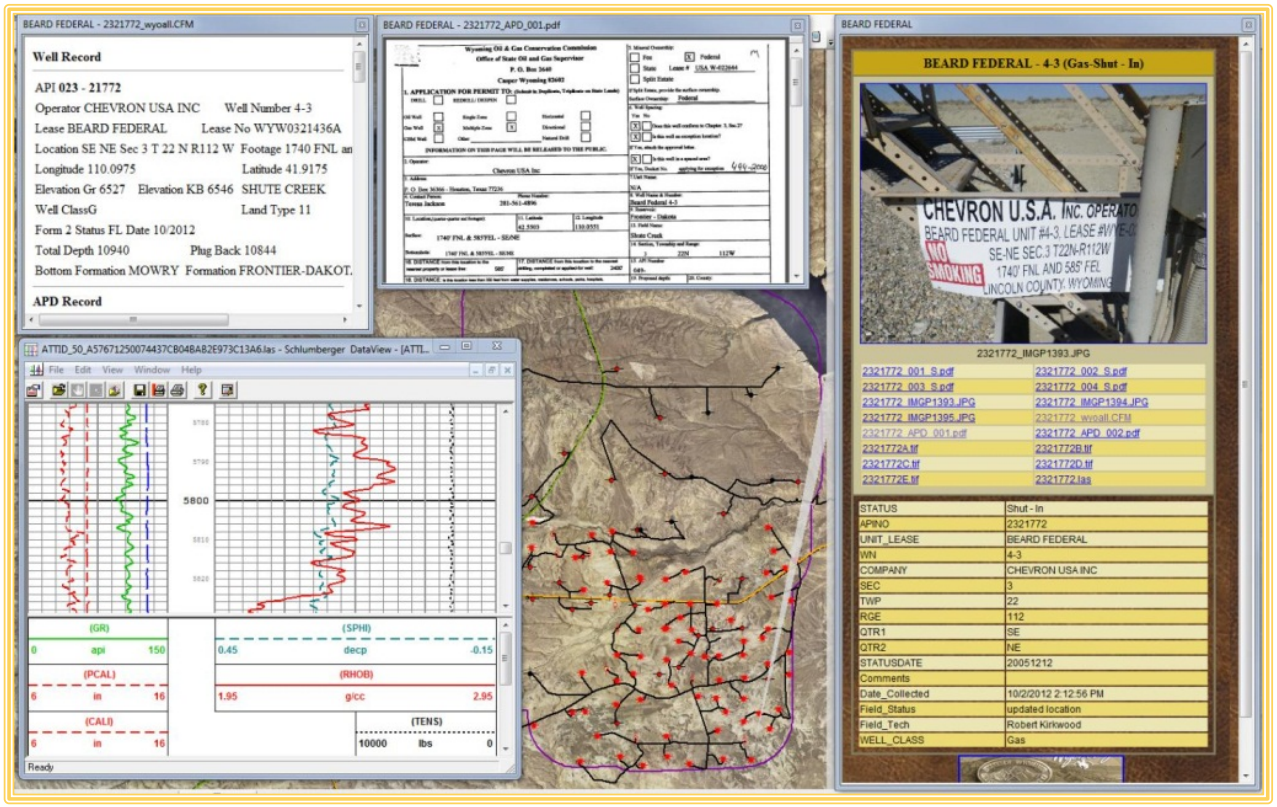

Figure 7. HTML pop-up and attachment tool provides all well catalog information.

The well catalogs for the Moxa arch AOR and Mahoney Dome AOR are available as Google Earth kmz files downloadable on the WSGS website (http://www.wsgs.uwyo.edu/Research/Energy/CO2.aspx) or in ArcMap format upon request from the WSGS. The well catalogs contain WOGCC wells, AOR polygons, landowner boundaries, roads, and tables that store relationships between all of the data. The well catalogs also contain photos, well permits, sundries, and well logs. All of these data are related to each well displayed in the maps.